

VYUŽITÍ PREDIKTIVNÍHO MODELOVÁNÍ PRO DETEKCI ÚNAVY ŘIDIČE

UTILIZATION PREDICTIVE SIMULATION FOR DETECTION REACTION OF DRIVER

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Anotácia: Táto štúdia pojednáva o možnostiach využitia simulačných systémoch v dopravných technológiách. Rozoberá možnosti simulačného systému ako systému pre zvýšenie vonkajšej bezpečnosti tak aj systému pre počítačové pozorovanie a pre monitorovanie ostražitosti vodiča za volantom. Dôvod na aplikovanie takéhoto systému bol hlavne predísť častým dopravným nehodám, ktorých príčina je veľmi často únava vodiča.

Kľúčové slová: bezpečnosť, modelovanie, únava

Anotation: Many traffic accidents are caused by failures in the interaction between the driver, the vehicle, and the traffic system. Thus, knowledge about these interactions is essential and this is especially true nowadays since the number of driving related interactions is increasing. The real world is of course the most realistic environment, but it can be unpredictable regarding, for instance, weather, road, and traffic, conditions. It is therefore often hard to design real world experiments from which it is possible to draw statistically significant conclusions.

Keywords: security, simulation, reaction time

1. INTRODUCTION

Many traffic accidents are caused by failures in the interaction between the driver, the vehicle, and the traffic system. Thus, knowledge about these interactions is essential and this is especially true nowadays since the number of driving related interactions is increasing. Today drivers also interact with different intelligent transportation systems (ITS), advanced driver assistance systems (ADAS), in-vehicle information systems (IVIS), and NOMAD devices such as mobile phones, personal digital assistants, and portable computers. These technical systems influence drivers' behavior and their ability to drive a vehicle.

To get knowledge on how these kinds of systems influence drivers, researchers conduct behavioral studies and experiments, which either can be conducted in the real traffic system, on a test track, or in a driving simulator.

The real world is of course the most realistic environment, but it can be unpredictable regarding, for instance, weather, road, and traffic, conditions. It is therefore often hard to design real world experiments from which it is possible to draw statistically significant conclusions. Some experiments are also too dangerous or impossible to conduct due to ethical reasons. Test tracks offer a safer environment and the possibility of giving test drivers more

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equivalent conditions, but they lack realism. Driving simulators on the other hand offer a quite realistic environment in which test conditions can be controlled and varied in a safe way.

Driving simulators are used to conduct experiments in many different areas. Examples include alcohol, medicines and drugs, driving with disabilities, human-machine interaction, fatigue, road design, and vehicle design. A driving simulator is designed to imitate driving a real vehicle. The driver interface can be realized with a real vehicle cabin or only a seat with a steering wheel and pedals, and anything in between. The surroundings are presented for the driver on a screen. It is important that the performance of the simulator vehicle, the visual representation, and the behavior of surrounding objects be as realistic as possible. For example, it is important that the ambient vehicles behave in a realistic and trustworthy way. In this article we present a traffic simulation framework that is able to generate and simulate these surrounding vehicles. Microscopic simulation of traffic is one possibility for simulating these ambient vehicles. Micro-simulation has become a very popular and useful tool in studies of traffic systems. Micro-simulation models are time discrete models which simulate individual vehicle/driver units. The behavior of vehicles/drivers and the interaction between those are simulated using different sub-models for car-following, lane-changing, speed adaptation, and so on. The sub-models use the current road and traffic situation as inputs and generate individual driver decisions regarding, for example, acceleration and preferred lane. An important difference between simulation of surrounding vehicles for a driving simulator and traditional applications of traffic simulation is that one of the vehicles is driven by a human being. This puts additional demands on the modeling of vehicle movements since it is the actual behavior of the simulated vehicles that is the primary output. Most traffic simulation models are designed for generating correct outputs at a macroscopic level, for example, average speeds or queue lengths. The models often include assumptions and simplifications that do not affect the model validity at the macro level but sometimes affect the validity at the micro level. One typical example is the modeling of lane-changing movements. In most simulation models vehicles change lanes instantaneously. This is not very realistic from a micro-perspective, but does not affect macro measurements appreciably.

2. THE SIMULATION FRAMEWORK

When simulating traffic for a driving simulator, the area of interest is the closest neighborhood of the driving simulator vehicle. It is only within this neighborhood that vehicles have to be simulated. The area of interest moves with the same speed as the simulator vehicle and can be interpreted as a moving window, which is centered on the simulator vehicle. We have developed a simulation framework for generation and simulation of vehicles within such a moving window.

The basic idea of the moving window is to avoid simulating vehicles several miles ahead of or behind the simulator vehicle, which is not efficient from a computational point of view. However, the window cannot be too small. First, the size of the window is constrained by the sight distance. The window must at least be as long as the sight distance, so that

vehicles do not pop up in front of the simulator vehicle. Second, the window must be large enough to make the traffic realistic and to allow for speed changes of the simulator vehicle.

2.1 Simulation and generation models

In order to be useful, the presented framework needs to be filled with suitable models for generation and simulation of vehicles.

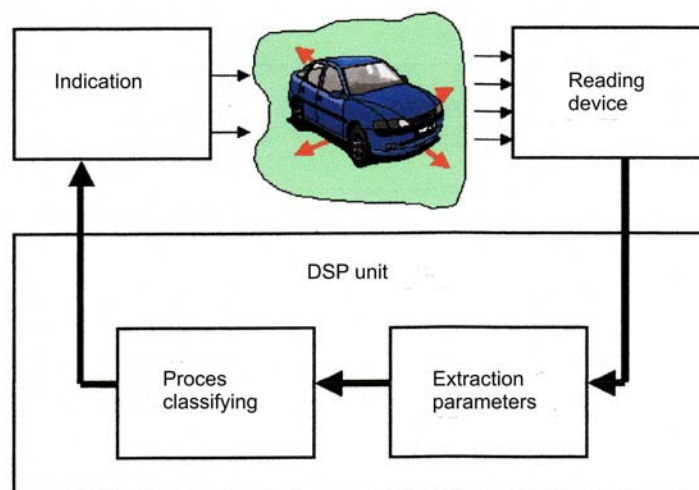


Fig. 1 - Simulation model

As in most micro-simulation models, vehicles and drivers are treated as vehicle driver units. These vehicle-driver units are described by a set of driver or vehicle characteristics. Both the vehicle and the driver characteristics vary among different vehicle types. The vehicle types used are cars, buses, trucks, trucks with trailer with 3-4 axes, and trucks with trailer with 5 or more axes.

- *Vehicle parameters* - The characteristics used to describe a vehicle are length, width, and the power to mass ratio, also called p-value. The p-value is the ratio between a vehicle's power, available at the wheels, and its mass. For all vehicle types except cars, the p-value describes the vehicle's maximum acceleration. For cars, the p-value describes the acceleration behavior at normal conditions. The average power/weight ratio for passenger cars is typically about 19 W/kg. A higher p-value can be used in special situations, for example in overtaking situations, in which car drivers tend to use higher acceleration rates. All vehicle parameters are assumed to be normally distributed within vehicles of a certain vehicle type,
- *Driver parameters* - The characteristics used to describe the driver part of the vehicle-driver units are basic desired speed and desired time gap. The basic desired speed is the speed that a driver wants to travel at on a dry, straight, and empty road. This speed is assumed to be normally distributed for drivers driving a certain vehicle type. When assigning a desired speed to a vehicle, the driven vehicle's acceleration capacity is checked. The vehicle has to be powerful enough to be driven at the desired speed. If that is not the case the vehicle-driver unit is assigned a new p-value. The desired time gap is the time gap that a driver wants to keep from a preceding vehicle in car-following situations.

The desired time gap is assumed to be log normally distributed for drivers driving a certain vehicle type,

- *Infrastructure speed adaptation* - The sub-model for determining a vehicle's desired speed at a section is based on the speed. This model describes speed adaptation on rural roads and has therefore been recalibrated for freeways. The model starts from a median basic desired speed, v_{max} . This median basic desired speed is then reduced with respect to speed limit, road width, and curvature to a median desired speed, v_{des} , for a specific section of a road.

2.2 Guidance system

We modeled the guidance system using fuzzy variables and rules. In addition to the steering wheel and vehicle velocity functionalities, we also consider variables that the system can use in adaptive cruise control (ACC) and overtaking capabilities. Among these variables are the distance to the next bend and the distance to the lead vehicle that is, any vehicle driving directly in front of the automated vehicle).

Car driving is a special control problem because mathematical models are highly complex and can't be accurately linearised. We use fuzzy logic because it's a well-tested method for dealing with this kind of system, provides good results, and can incorporate human procedural knowledge into control algorithms. Also, fuzzy logic lets us mimic human driving behavior to some extent.



Fig. 2 – The adaptive cruise control

2.3 Steering control

The steering control system's objective is to track a trajectory. To model lateral and angular tracking deviations perceived by a human driver, we use two fuzzy variables – Lateral Error and Angular Error. These variables represent the difference between the vehicle's current and correct position and its orientation to a reference trajectory. Both variables can take left or right linguistic values. Angular Error represents the angle between the orientation and vehicle velocity vectors. If this angle is counterclockwise, the Angular Error value is left. If the angle is clockwise, the Angular Error value is right. Lateral Error represents the distance from the vehicle to the reference trajectory. If the vehicle is positioned on the trajectory's left, the Lateral Error value is left; it's right if the vehicle is on the right.

2.4 Speed control

To control speed, we use two fuzzy input variables – Speed Error and Acceleration. To control the accelerator and the brake, we use two fuzzy output variables - Throttle and Brake.

The Speed Error crisp value is the difference between the vehicle's real speed and the user-defined target speed, and the Acceleration crisp value is the speed's variation during a time interval. The throttle pressure range is 2–4 volts, and the brake pedal range is 0–240 degrees of the actuation motor. Throttle and brake controllers are independent, but they must work cooperatively. Activating the two pedals produces similar outcomes and can:

- increase the target speed (stepping on the throttle or stepping off the brake on downhill roads),
- maintain speed (stepping on or off either pedal when necessary),
- reduce the vehicle's speed - downshifting the throttle or stepping on the brake.

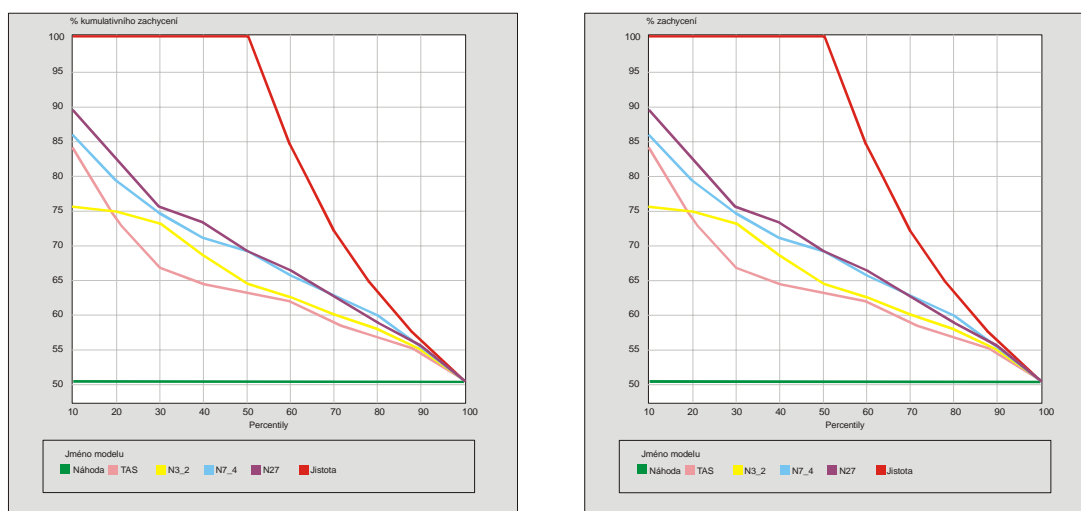


Fig. 3 - Measurement exact valuation simulators

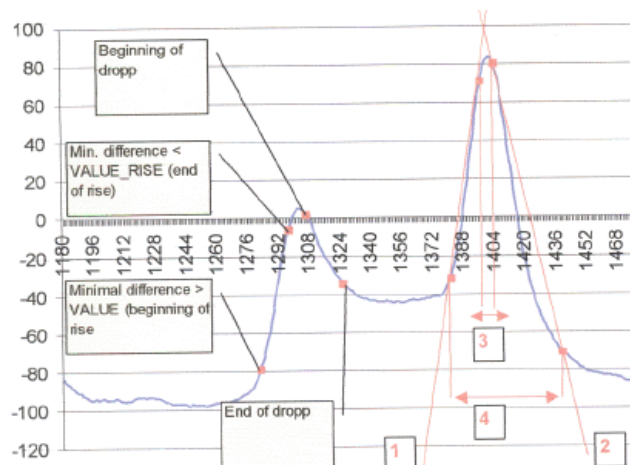


Fig. 4 – Measured properties of EOG

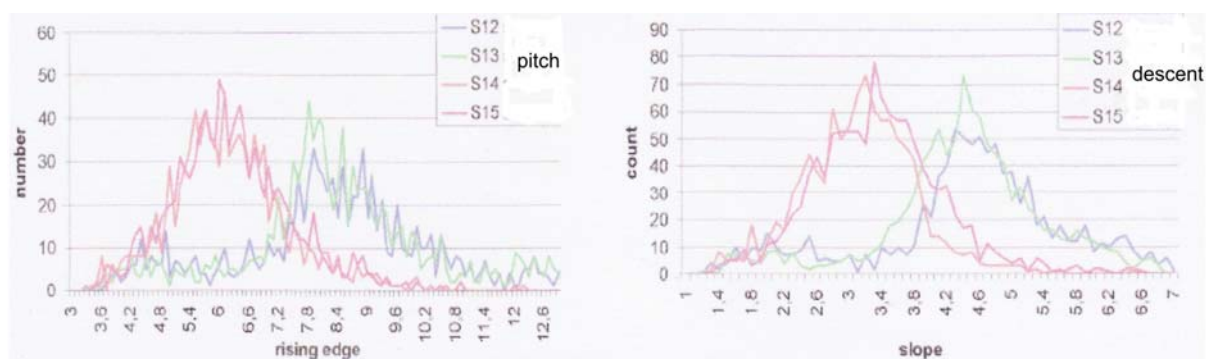


Fig. 5 – Slope of ...

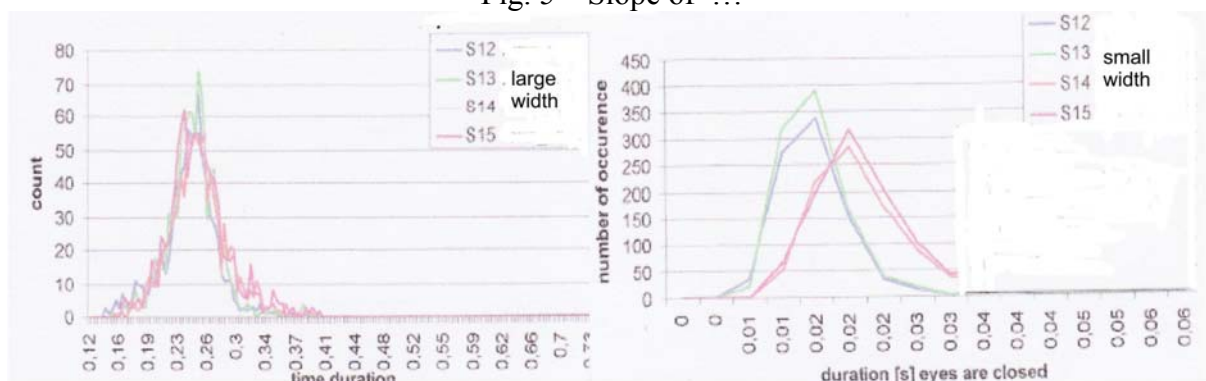


Fig. 6 – Duration of ...

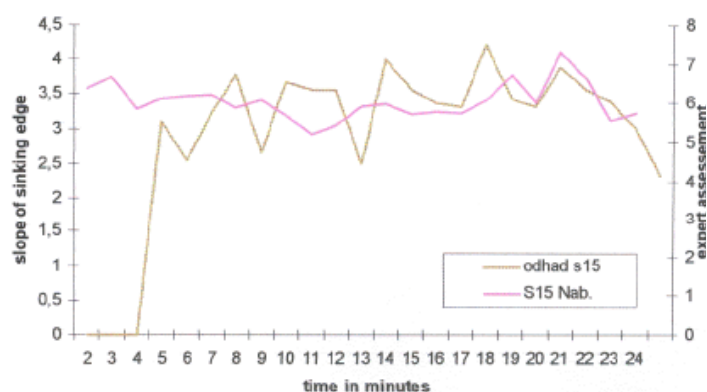


Fig. 7 – Rising edge and expert assessment

CONCLUSION

The simulation framework presented in this article is able to generate and simulate surrounding traffic for a driving simulator on rural roads and on freeways. The model generates realistic streams of vehicles both in the same and the oncoming direction as the simulator vehicle. The validation study showed that the framework is able to create realistic traffic situations on rural roads and on freeways in terms of a realistic number of active and passive catch-ups. The only question mark is active catch-ups on freeways, which seem to be too few due to a too high lane-changing frequency. Thus, the lane-changing model has to be enhanced. The comparison of traffic flows and computational times verified that the framework is able to achieve the target flow and that there is a gain in computational time when using the candidate areas compared to only using one large simulated area.

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